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The Effect of Diboracy (Digital Book Containing Scientific Literacy) in Reducing Misconceptions on Newton's Law of Gravity

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Abstract

The low utilization of technology and scientific literacy skills lacking in the classrooms remain a major problem in the learning and teaching process, specifically in influencing students' conceptual understanding. This research aims to analyze the effect of Diboracy (Digital Book Contained Scientific Literacy) in reducing misconceptions in Newton's law of gravity. This research uses experimental research design with one group pre-test-post-test conducted on research subjects which were selected through random sampling technique. The sum of the research subjects include 38 students. The data instruments include tests and non-tests instruments. The test distributed is in the form of multiple choice questions equipped with CRI to measure the misconceptions, while the non-test assessment takes form of questionnaires to determine students' responses to Diboracy. Data analysis was performed through t-test on student learning outcomes and the students' questionnaire responses which resulted in the average percentages. Based on the analysis, it can be concluded that: (1) there is an effect in reducing students' misconceptions when Diboracy is implemented, specifically regarding Newton's law of gravity; (2) students give better responses to Diboracy than textbooks.

Keywords: diboracy; misconception; newton's gravity

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INTRODUCTION

The development of technology in the 21st century has changed the paradigm of education which has been focusing on teaching to learning (Afandi, Junanto, and Afriani, 2016). The implementation of education which is adaptive to technological developments also encourages every human being to have the skills to be able to compete in various sectors of life. One of the skills referred to is scientific literacy skills (Nofiana and Julianto, 2018). Science and technology are the most prominent characteristics needed in the modern world, and thus, scientific literacy is a requirement that must be possessed by every individual (Vieira, Melo, Avraamidou and Lobato, 2017), especially students. Students are required to master literacy to understand laws, theories, and phenomena, as well as to comprehend the basis of scientific knowledge needed to make decisions (Dragoş and Mih, 2015).

However, Indonesia's participation in PISA (Program for International Student Assessment), which has been conducted for more than a decade, still places the scientific competence of Indonesian students in the low category. In 2018, Indonesia was ranked 62 out of 71 countries with the average score of students in the science field below the OECD (Organization for Economic Cooperation and Development) average score, which is 396 out of 489. Weak scientific competence results in weak understanding of science concepts

(OECD, 2019), which tends to cause misconceptions or misunderstandings of the science concepts (Aulia, Diana, and Yuberti, 2018).

Misconception is an initial concept as a result of knowledge construction that is not in accordance with scientific concepts (Alhinduan, Kurniawan, and Muliyani, 2016; Suparno, 2013). Physics, as a branch of science that emphasizes mastery of concepts for intellectual abilities (Saputri & Nurussaniah, 2015), in fact, tends to contain misconceptions in all areas of study (Wandersee, Mintez, and Novak, 1994), such as in the material of Earth and Space Sciences (Fauzia and Madlazim, 2015), Regular Circular Motion (Annisa, Astuti, and Mindyarto, 2019), Newton's Law (Zulvita, Halim, and Kasli, 2017), Heat Temperature (Zayyinah, Munawaroh, and Rosidi, 2018), and Energy Effort (Maison, Lestari, and Widaningtyas, 2020). The factors causing high level of misconceptions in the field of physics studies include the cognitive abilities of students, the teacher's ability and mastery of material, the context of learning, teaching methods and textbooks (Suparno, 2013).

Out of the five causes of these misconceptions, Simanek (2016) stated that didacticogenic misunderstanding (internal misunderstanding due to the learning system) caused by textbooks is the main cause of misconceptions. The use of textbooks as a cause of misconceptions in physics lessons can be caused by the language used in presenting material such as in translated textbooks (Zajkov, Zajkova, and Mitrevski, 2016). The main source of textbooks that cause misconceptions can also come from unclear illustrations or inappropriate use of images (Gurel, Eryilmaz, and Dermott, 2015), which may affects students' conceptual understanding.

Efforts to reduce misconceptions in the topics of physics have been carried out by many researchers, including by applying various learning models (Kesuma, Diani, Hasanah, and Fujiani, 2020; Rosuli, Koto, and Rohadi, 2019), different approaches in teaching the students (Parwati, Makhrus, and Gunada, 2019)), as well as approaches to teachers (Ilyas and Saeed, 2018; Kurniawan and Maryanti, 2018). Even the use of technology as an effort to reduce misconceptions in physics material has also been carried out (Hidayatulloh, Wiryokusumo, and Walujo, 2019; Kurniawan, Muliyani, and Nassim, 2019; Ozkan and Selcuk, 2015). However, so far, there has not been much research in efforts made to reduce misconceptions through scientific literacy, especially on Newton's law of gravity. In fact, Neidorf, Arora, Erberber, Tsokodayi, and Mai (2020) stated that the misconceptions experienced by students were mostly related to the topic of gravity. Additionally, Syuhendri (2019) states that knowledge and concepts found on the topic of gravity often lead to misconceptions. Therefore, this research was carried out by combining technological advances through the use of Diboracy in reducing students' misconceptions in Newton's law of gravity. This study aims to describe the effect of Diboracy in reducing misconceptions in Newton's law of gravity.

METHOD

This research utilized an experimental research design with a pre-experimental one group pre-test and post-test design. Through random sampling technique, 38 students of Grade X Science 7 students of a senior high school in Banjarmasin were selected as the research subjects. Diboracy was implemented on the topic of Newton's law of gravity with three study sessions covering 4 indicators: (1) analyzing the gravitational force between two objects using Newton's Law of Gravity equation based on indicators of conceptual knowledge in scientific literacy; (2) analyzing the gravitational acceleration between the two planets based on conceptual knowledge indicators on scientific literacy; (3) analyzing the orbital speed of the satellite based on conceptual knowledge indicators on scientific literacy; and (4) analyzing the period of planetary revolution based on indicators of facts and/ knowledge of concepts on scientific literacy.

The type of the data collected in this study are quantitative data and qualitative data with the data collection instruments include tests and non-test instruments. Quantitative data were obtained from the learning outcomes test (LOT) of students prior (pre-test) and after (post-test) using Diboracy, in the form of 10 multiple choice question items equipped with CRI (Certainty of Response Index) with a confidence level scale from 0-5 (Table 1). Meanwhile, the qualitative data were obtained from non-test instruments in the form of questionnaires containing 25 statement items with five indicators: (1) students' enthusiasm in learning; (2) comprehensibility of the material; (3) material substance; (4) convenience in obtaining information; (5) use of visual media/illustrations is as needed. The data from the pre-test and post-test results were then analyzed to determine the percentage of the criteria of students who understood the concepts, those who had misconceptions, and those who did not understand the concepts. Meanwhile, the questionnaire result data was used to explore the students' responses on the implementation of Diboracy.

Table 1. The Criteria of Concept Understanding Based on the CRI Index (Hasan, Bagayoko, & Kelley, 1999)

Criteria	Low CRI (< 2.5)	High CRI (> 2.5)
Correct answer	Correct answer and the CRI is low; did not understand the concept (lucky guess)	Correct answer and the CRI is high, understands the concept well
Incorrect answer	Incorrect answer and the CRI is low; did not understand the concept	Incorrect answer and the CRI is high; misconception

The qualitative data in this study were obtained from a response questionnaire prior and after the implementation of Diboracy. The use of response questionnaires aims to explore students' responses on the use of Diboracy in reducing misconceptions.

Table 2. The Criteria of Responses on Textbooks and *Diboracy* (Adapted from Akbar, 2016)

No	Average Score (%)	Category
1	$80.01 - 100.00$	Excellent
2	$60.01 - 80.00$	Well
3	$40.01 - 6.00$	Quite well
4	$20.01 - 40.00$	Poor
5	$0.00 - 20.00$	Very Poor

Based on the r table and the moment product reliability value, the instrument is declared valid if it gets a minimum score of 0.31. Moreover, it is also declared reliable if it gets a minimum score of 0.60. The validity and reliability of the instruments used in this study are presented in Table 3.

Table 3. The Validity and Realibility of the Instruments

Instruments	Validity	Reliability	Category
LOT	0.53	0.60	Valid and Reliable
Survey Responses	0.54	0.88	Valid and Reliable

The normality test in this study utilized the Shapiro-Wilk test. The data is assumed to be normally distributed if the Asiymp value. Sig (2-tailed) is greater than 0.05. Meanwhile, to determine the effect of Diboracy in reducing misconceptions, a t-test was carried out through the criteria of significance level (α) = 0.05 or 5% with the following conditions: (1) Ho is accepted if Sig> 0.05, or t count ≤ t table; and (2) Ho is rejected if Sig <0.05, or t coun t> t table. The statistical hypothesis tested in this study is (1) H0: There is no effect on the implementation of Diboracy in reducing misconceptions about Newton's law of gravity; and (2) Ha: There is an effect on the implementation of Diboracy in reducing misconceptions in Newton's law about gravity.

RESULTS AND DISCUSSION

Table 4 illustrates the number of students based on the conceptual understanding criteria during the pre-test and post-test. Meanwhile, Table 5 presents the percentage of students' conceptual understanding as a whole, which is then divided into understanding concepts, not understanding concepts, and had misconceptions before and after using Diboracy.

Table 4. Number of Students Based on Criteria for Understanding the Concept of Each Question Item Before (Pre-test) and After (Post-test)

Indicator	Question no.	Pre-test			Post-test		
		U	NU	MC	U	NC	MA
1	1	17	11	10	34	1	3
	2	2	15	21	27	2	9
	3	4	16	18	30	3	5
2	4	4	15	19	21	5	12
	5	5	15	18	31	2	5
3	6	15	8	15	35	2	1
	7	0	13	25	5	6	27
4	8	0	18	20	17	2	19
	9	9	11	18	23	3	12
	10	0	19	19	21	2	15

Note= U: Understood; NU: Not understood; MC: Misconception

Table 5. The Percentage of Cognitive Achievement Prior and After Taught Using *Diboracy*

Level of Comprehension	Percentage (%)		ΔDifference (%)
	Pre-test	Post-test	
Understood	14,73	64,21	49,48
Not Understood	37,11	7,37	-29,74
Misconcept	48,16	28,42	-19,74

Based on Table 5, it was known that there was an increase in students' conceptual understanding, which was 49.48% after using Diboracy. The increase in students' understanding of this concept was accompanied by a decrease in the percentage of students who experienced misconceptions and did not understand the concept, respectively, namely 29.74% and 18.74%. For more detail, the cognitive achievements of students on each indicator which include misconceptions, not understanding concepts, and understanding concepts are shown in Figure 1.

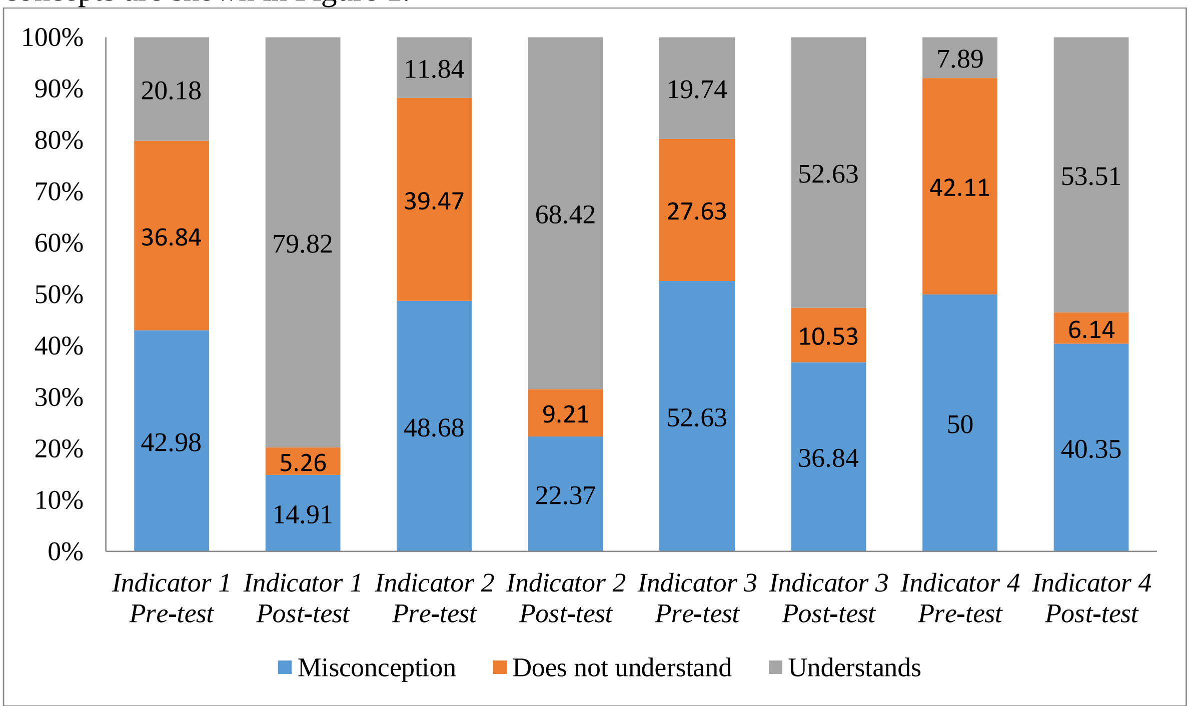

Figure 1. The Percentage of Students' Conceptual Understanding Scores per indicator before (pre-test) and after (post-test) using Diboracy is showed above

Based on the normality test that has been carried out, the data obtained is shown in Table 6.

Table 6. The Data Results of the Normality Pre-test Post-test

Data	Significance
Pre-test	0.085
Post-test	0.697

Since the significance value obtained was greater than 0.05, the two data are normally distributed. Next, the paired t-test was carried out to determine whether or not the influence of Diboracy was present in reducing students' misconceptions. The pre-test and post-test of the students' tests are presented in Table 7 below.

Table 7. The Analysis of the T-Test Results

Pre-test	Average Post-test Score	t-test	t table	Significance
9.78	61.30	19.804	1.68709	0.00

The Table 7 showed that the acquisition of t count, which was greater than t table, was reinforced by the significance of 2 parties which are smaller than 0.05. The hypothesis regarding the influence of Diboracy in reducing misconceptions in Newton's law of gravity is thus acceptable. The decreased level of misconception and the increased achievement of students' conceptual understanding on the pret-test and post-testss were then analyzed by comparing the results of students' responses to the use of textbooks and Diboracy.

Table 8. Comparison on Students' Responses towards Textbooks and Diboracy

No	Responses Indicators	Textbooks (%)	Diboracy (%)
1	Enthusiasm in learning	33	82
2	Easeness in comprehending the Materials	38	97
3	Material substances	38	74
4	Easemess	62	92
5	Use of visual media or intro sentic as needed	44	87
	Average	**43**	**70,4**
	Category	**Quite Good**	**Good**

Based on the data in Table 8, it is confirmed that there is an increase in students' enthusiasm for learning into 82%. This increase was supported due to the ease felt by students in understanding the material of Newton's Law of Gravity. One of the factors reviewed is the use of foreign terms such as, "Let's See", "Let's Try", and "Let's Fight", which have been commonly heard and used by students. In addition, vocabularies such as Goldilocks, Retrograde, and Light Years related to Newton's Law of Gravity have been adapted to the cognitive abilities of learners. Typographic aspects include typeface (Dogusoy, Cicek, and Cagiltay, 2016), font size (Franken, Podlesek, and Mozina, 2015), spacing (Hojjati and Muniandy, 2014), and color and background (Anuardi, Shinohara, and Yamazaki, 2016) is also a supporting factor that makes it easier for students to understand the material.

Diboracy uses two fonts in the Sans Serif category, namely Calibri (body) and Just Another Hand, which had a significant impact on the aspect of readability (ease of reading and understanding of text) (Hojjati and Muniandy, 2014), and thus, it is appropriate to use on text displayed on a computer screen (Moret-Tatay and Perea, 2011). Sans Serif group fonts also help students to read text more quickly and accurately (Dogusoy et al., 2016). Judging by the size of the letter, in general, Diboracy uses the font size 14. This is in line with a research conducted by Banerjee and Bhattacharyya (2011) which stated that students can read faster at font size 14. Diboracy also uses double spacing in order to ease students to read the text more carefully, and make it easier for students to recognize and start each sentence (Hughes and Wilkins, 2002). Therefore, the use of double spaces is highly recommended (Blackmore-Wright, Georgeson, and Anderson, 2013; Hojjati and Muniandy, 2014). The layout on Diboracy is dominated by lazuardi (sky blue color), which plays a role in stimulating and improving students' cognitive understanding (Xia, Song, Wang, Tan, and Mo, 2016)) with a white background which also has a positive impact on readability (Keček, Zorko , Čerepinko, Tomiša, and Valenko, 2017).

The substance of the material in Diboracy refers to the learning objectives that have been planned and presented in a systematic manner and is equipped with discussion activities at the end of each sub-material. Diboracy contains indicators of scientific literacy which include science as a body of knowledge, science as a way of investigating, science as a way of thinking, and interactions between science, technology and society (interaction of science, technology, and society).

Figure 2. Science as a body of knowledge (presenting a concept)

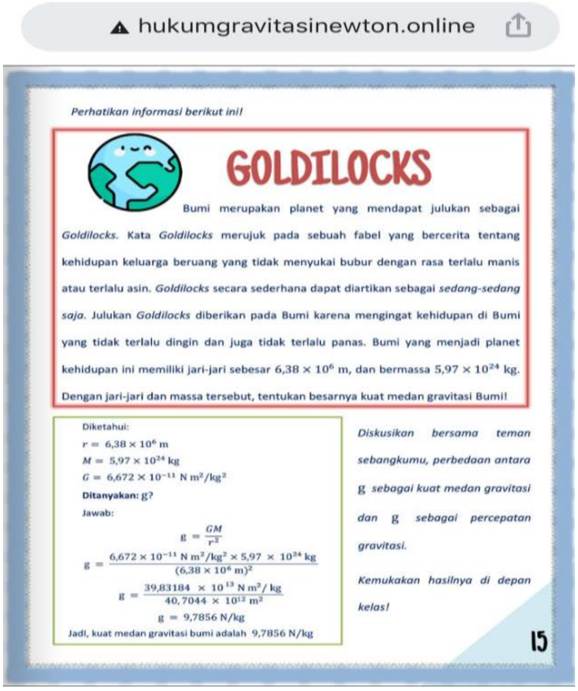

Figure 3. Science as a way of investigating (thinking activity)

Figure 4. Science as a way of thinking (cause-and-effect situations)

Figure 5. Interactions of science with technology, and society

The content of scientific literacy in Diboracy enriches knowledge and information on the topic of Newton's law of gravity, which resulted in broadening and deepening the students' concept of scientific understanding (Fananta et al., 2017). This is in line with several studies Yunita and Nana (2020); Tarmizi, Halim, and Khaldun (2017) which state that increasing students' conceptual understanding will reduce student misconceptions.

The aspect of the convenience of finding information has also increased. Information given through the Literacy Corner feature and the *Tau Gak, sih?* column presents scientific figures and the history of the birth of Heliocentric theory as well as the background in the formulation of Kepler's Law. Diboracy also presents job prospects in the field of Astronomy and the current impact of the rapid development of science and technology. This information is important to know as it is able to stimulate students' curiosity, increase enthusiasm for learning, and help understand physics concepts, so as to reduce misconceptions and have a positive impact on student academic achievement (Aina, 2013; Berman and Kuden, 2017; Shin, Lee, and Ha, 2017). In addition, Diboracy also reduces the role of text and prioritizes the use of visual media such as illustrations for planets, animations of rotational movements and revolutions of celestial bodies, to videos related to physics equations and the history of science. The use of visual media aims to make it easier for students to process information (Sharif, Wills, and Sargent, 2010; Vijaya, 2018) and help reduce misconceptions (Samsudin, Liliawati, Sutrisn, Suhendi, and Kaniawati, 2014).

CONCLUSION

Based on the analysis and discussion elaborated above, it is concluded that: (1) there is an effect caused by teaching using Diboracy in reducing student misconceptions, especially regarding Newton's law of gravity; (2) students give better responses to the use *of* Diboracy than textbooks.

RECOMMENDATION

The results of this study have implications for reducing misconceptions in physics lessons, especially on Newton's law of gravity. It is hoped that similar research will be carried out by carrying out scientific literacy integrated contents in the learning process combined with technology as an effort to reduce misconceptions in other physics materials

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